InAs-Based Bipolar Transistors

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We present materials, physics and device results pertaining to bipolar transistors based on InAs. The materials and structures were grown by MBE on InAs substrates. The following findings have resulted from our InAs-based bipolar transistor research.

- Initial efforts optimized MBE growth parameters through the use of 77K photoluminescence.
- pn diode growth and fabrication was undertaken to examine I-V curves, paying special attention to reverse leakage current. pn diodes formed by using the background n-type doping for the n layer had much lower reverse leakage current than did similar structures formed with silicon doped n-type layers.
- The fact that nearly ideal I-V curves, with low reverse leakage current, could be obtained in pn junction mesa structures suggests that no inversion layer exists on the surface of p-type InAs, in contrast to the popularly held view that the Fermi level is pinned in the conduction band of InAs.
- The traditional implementation of bipolar transistors in III-V materials uses the heterojunction bipolar transistor (HBT) design, which employs a (nearly) lattice-matched type I heterojunction. A second bipolar transistor design, the tunneling emitter bipolar transistor (TEBT), requires a similar type of heterojunction. Such a heterojunction is not available in the InAs material system, so we have investigated mismatched type I heterojunctions. The initial heterojunction investigated was mismatched (tensile strained) AlInAs on InAs. Critical thicknesses for cracking / dislocation of $Al_xIn_{1-x}As$ on InAs have been measured to be in the range of 35 Å for x=40%, and 450 Å for x=10%.
- Npn bipolar junction transistors (BJT's) employing just homojunctions have produced common emitter current gains (β) as high as 100. Similar HBT's, with $Al_{0.1}In_{0.9}As$ emitters, produced similar values of β. Npn TEBT's showed a trend of decreasing β with increasing barrier thickness; the opposite trend was observed in pnp TEBT's.

This work was supported by DARPA and ONR (C.E.C. Wood) and the AFRL Palace Knight Program.